RANCHI UNIVERSITY

UNIVERSITY DEPARTMENT OF GEOLOGY

Ph.D. SYNOPSIS

TITLE OF PROPOSED Ph.D. RESEARCH WORK

TECTONO-METAMORPHIC EVOLUTION OF ROCKS IN GURABANDA AREA, DISTRICT-EAST SINGHBHUM, JHARKHAND.

A synopsis submitted to the University Department of Geology, Ranchi University, Ranchi, Jharkhand in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

In

Geology (Science)

Under the supervision of

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INTRODUCTION

Tectono-metamorphic evolution refers to the progressive changes in rocks due to combined tectonic and metamorphic processes over geological time. It involves the interaction between deformation (tectonism) and metamorphism, influencing the mineralogy, texture, and structure of the rocks in response to varying pressure (P), temperature (T), and stress conditions.

This process is commonly observed in orogenic belts, shear zones, and subduction zones, where rocks experience multiple deformation and metamorphic events due to plate tectonic movements. The evolution of these rocks follows a pressure-temperature-time (P-T-t) path, which helps geologists reconstruct the geodynamic history of a region (Singh et al., 2021).

The study of tectono-metamorphic evolution is essential for understanding the geological history and processes that form the Earth's crust. This research investigates the relationship between deformation, metamorphism, and magmatism in metamorphic areas, focusing on the pressure-temperature-time (P-T-t) evolution of rocks under different tectonic conditions (Pathak et al. 2024).

Metamorphic rocks record the past orogenic events, showing changes caused by tectonic forces. Studying their mineral, structural, and chemical traits helps understand how these rocks formed and offers insights into crustal evolution and lithospheric dynamics.

This study aims to uncover the tectono-metamorphic history of a specific geological area by combining petrological, geochemical, geochronological, and structural analyses. It seeks to enhance understanding of regional metamorphism and crustal changes.

This research helps understand the geological development of orogenic belts and shear zones, where many events have affected earlier structures. The results will improve our knowledge of crustal processes and may impact resource exploration and geotechnical studies.

STATE OF THE ART

Gurabanda, located in East Singhbhum, Jharkhand, is part of the Singhbhum Shear Zone (SSZ), is a region known for its complex tectono-metamorphic evolution**.** The area has undergone multiple phases of deformation and metamorphism (Misra and Johnson, 2005), primarily associated with Proterozoic orogenic events.

A comprehensive study examined the gold metallogeny of the Singhbhum crustal province, emphasizing the implications of tectono-metamorphic events during the Archean-Proterozoic transition (Singh et al., 2021).

Research by Sahu et al., 2018, focused on the study of emerald occurrences in and around the Gurabanda area highlightening the lithological and structural controls on emerald genesis.

Research conducted by Singh and Minz, 2022[a], provided insights into the exploration implications of gemstones within the Singhbhum crustal province.

The findings highlights the importance of Metamorphism-Mineralization relationship.

This research will further provide significant insights into the region's Tecto-Metamorphic evolution deciphering aspects that may be economically significant related to mineralization and resource exploration.

ABOUT THE AREA:-

The area of investigation is Gurbandha Block in East Singhbhum District, Jharkhand. It is 75kms from Jamshedpur City and connected by NH-33, 35kms from Dalbhumgarh railway station towards SE. East Singhbhum District is located in the southeast part of Jharkhand State, covering an area of 3533 sq. km. It is bounded by longitude 86˚04' E To 86°54'E and latitude 22°12' N To 23°01' N. It falls under Survey of India toposheet no. 73 J/01-03, J/05-12, J/14-16.

The study area, Gurabanda, covers 367 hectares (3. 67 sq. km) with coordinates 22°21'50.73" N latitude and 86°32'27" E longitude. It can be accessed by both roadways and railways.

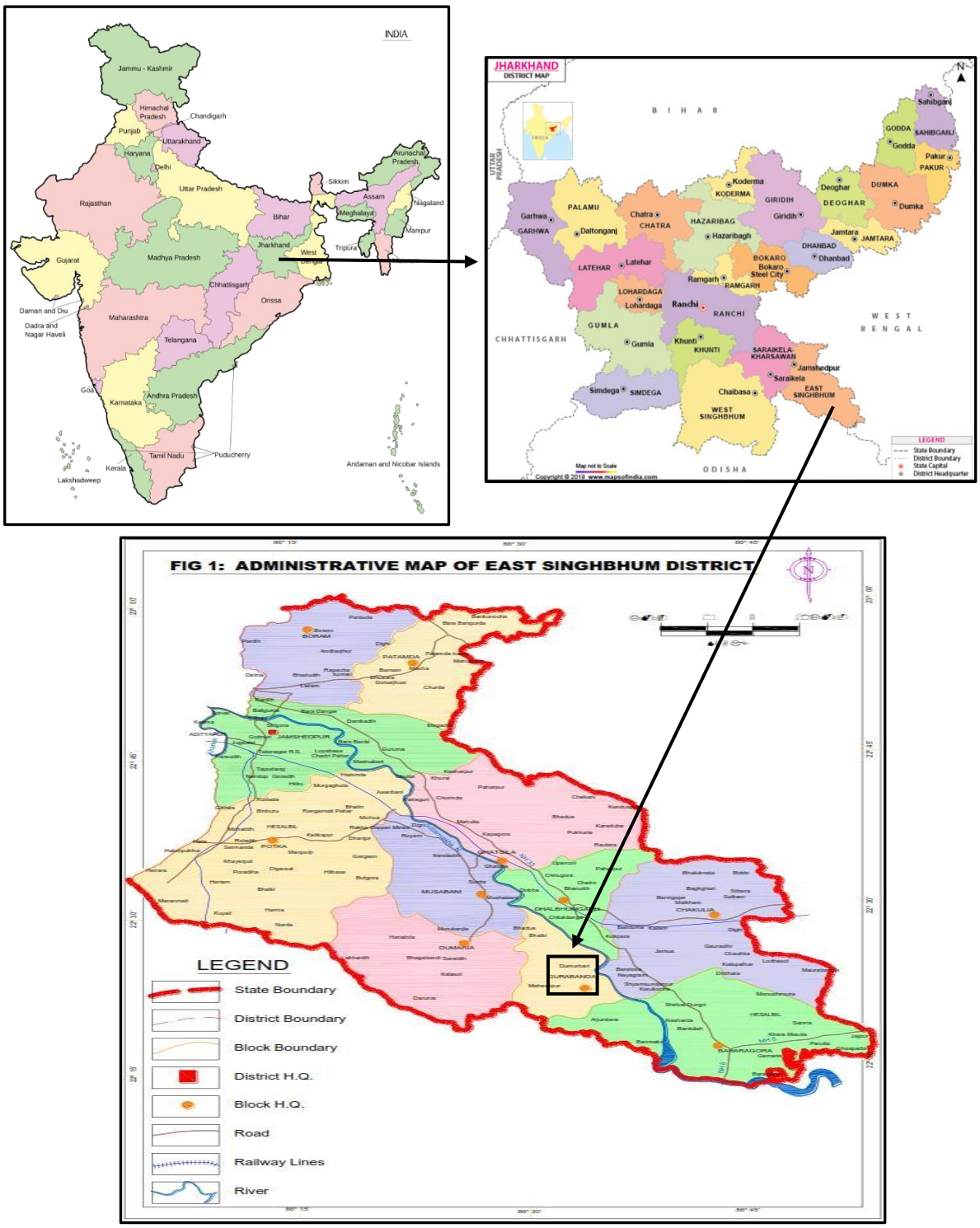

Fig1: Location Map of the Area

GEOLOGY

Generalised chronostartigraphic Succession in the Singhbhum-Orissa craton (after Saha et al.,1998).

Group	Formation	Member(Litho units)	Age
		Newer Dolerite dykes & sills	1600-950Ma
		Mayurbhanj Granite	2100Ma
		Gabbro-anorthosite-ultramafic Rocks	2100-2200Ma
Kolhan			
----------Unconformity----------			
Dhanjori			
		Jagannathpur,Malangtoli,Dhanjori and Simplipal lavas,quartzites, Conglomerates	2300Ma
Singhbhum	Dalbhum	Pelitic and arenaceous Metasediments with	
	Chaibasa	mafic sills.	2300-2400Ma
----------Unconformity----------			
	Singhbhum Granite (Phase-III)	Epidiorite(Intruisves)	3100Ma
		Upper shales with sandstones and Volcanic rocks	
Iron Ore		Banded hematite jasper with iron ore	
		Sandstone and conglomerate	
----------Unconformity----------			
	Singhbhum Granite (Phase II and I)	Nilgiri Granite	3400-3500Ma
		Bonai Granite	3775 Ma
Older Metamorphic (OMG)	Metamorphic	Pelitic schists,quartzites, para amphibolite, ortho amphibolite	4000Ma

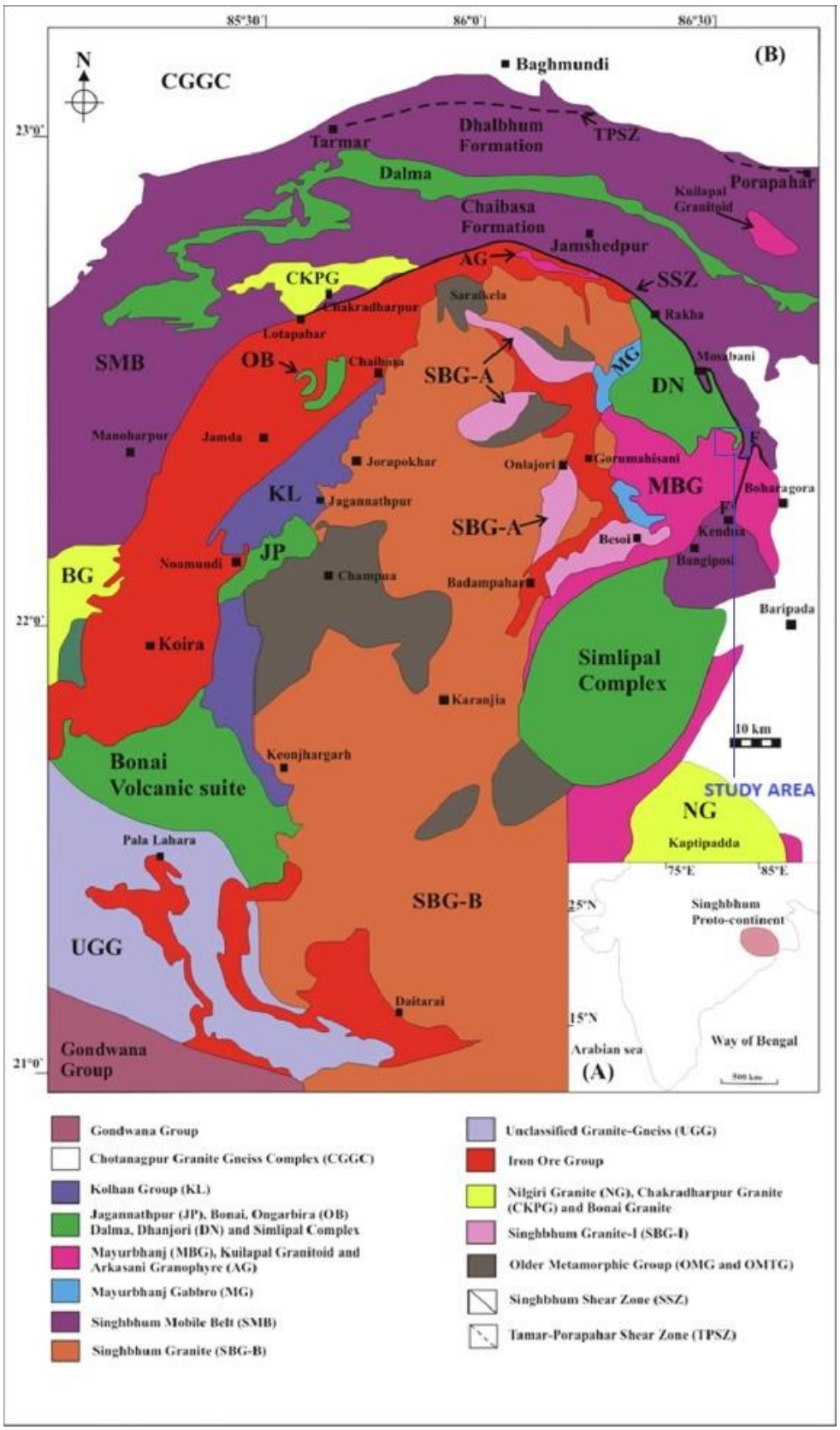

Fig 2. Local geological map of east Singhbhum craton showing the study area (After Saha, 1994).

PROBLEMS TO BE INVESTIGATED:-

Problems to be investigated are as follows:

1. Vague/Unclear Metamorphic History: The exact pressure-temperature conditions and P-T-t paths of metamorphism in different parts of the SSZ are not well established.
2. Fluid-Rock Interaction: The role of fluids in metamorphic transformations and their impacts on mineralization in the Singhbhum Shear Zone is obscure (Minz and Singh, 2022)
3. Economic Mineralization and Metamorphism: The link between Shear Zone Metamorphism and mineralization (gold, uranium, various types of gems, REEs) needs further investigation.
4. Lack of Experimental and Numerical Modeling of Metamorphism.

HYPOTHESIS

1. The Gurabanda area might have undergone multiple deformation phases due to its proximity to the Singhbhum Shear Zone (SSZ).
2. The area might have experienced various grades of metamorphism.
3. The ductile deformation in the Gurabanda area may be associated with mylonitization, folding, and thrusting, indicating a history of intense shear zone kinematics (Sahu et al., 2018).
4. The shear zone-controlled metamorphic evolution might have played a significant role in fluid movement and ore deposition,influencing the formation of gold, uranium, gems and sulfide mineralization.

OBJECTIVE OF THE INVESTIGATION AND MOTIVATION:-

The research will be carried out with the following objectives in detail:

1. To carry out the Petrological and Geochemical study of the rocks from the study area.
2. To decipher the Metamorphic Facies and P-T Conditions of the area.
3. Deciphering structural and tectonic role in metamorphic evolution.
4. To construct relationship Between Metamorphism and Mineralization.
5. Comparision with Other Shear Zone-Related Metamorphic Terrains.
6. To evaluate the economic significance of metamorphic terrains.

RESEARCH DESIGN AND METHODOLOGY:-

The research is structured into the following:

- **Literature survey**
- **Field survey**
  - Field data collection
  - Photography
  - Systematic sampling of rocks
  - Proper storage for the sample
- **Laboratory Study**
  - Petrographical study of rock samples using high definition microscope.
  - Geochemical analysis of the rock samples using XRD, XRF, EPMA, Raman spectroscopy, EPMA, SEM-EDS (as per practible).
  - Thermobarometry & P-T Path Reconstruction using THERMOCALC, Perple_X software (as per practible).

TOOLS TO BE USED IN COLLECTION OF DATA:

1. Handheld GPS
2. Survey of India Toposheet
3. Rock hammer and chisel
4. Handlens
5. Field diary
6. Brunton compass/ clinometer
7. High definition petrographic microscope
8. Geographic Information System (GIS)
   (Proposed tools and others may be used as per their availability).

SIGNIFICANCE OF THE STUDY:-

Studying the tectono-metamorphic evolution of this region holds significant scientific, economic, and geodynamic importance.

- Understanding the Geological Evolution of the Singhbhum Shear Zone.
- Contribution to Metamorphic and Structural Geology
  - Studying petrological and geochemical aspects of metamorphic rocks helps in delineating facies, grades, P-T-t path of metamorphism.
  - Structural analysis shows deformation's intensity and nature in the shear zone.
- Economic Significance: Mineralization and Resource Exploration.
  - Understanding the tectono-metamorphic history aids in predicting the distribution of economically valuable minerals.
  - The hydrothermal alteration and fluid movement associated with shear zones play a key role in mineralization processes.

ITS RELEVANCE TO THE PRESENT DAY PROBLEM AND NEED OF THE SOCIETY:-

I. Resource Identification: Understanding the tectono-metamorphic evolution helps in predicting mineralization zones, aiding in efficient and sustainable mining practices.
II. Impact of Shear Zones on Groundwater Flow: Shear zones control groundwater movement, influencing aquifer recharge and water quality. Understanding the rock permeability and fracture networks aids in groundwater conservation and pollution prevention.
III. Education and Skill Development: Universities and research institutions can use the region as a natural laboratory for studying orogenic belts, metamorphic petrology, and tectonics. Encouraging local student engagement in geosciences can help build a skilled workforce for geological and environmental sectors**.**

CONTRIBUTION TO THE EXISTING KNOWLEDGE:-

The study of the tectono-metamorphic evolution of the Gurabanda area, East Singhbhum, could significantly enhance our understanding of Proterozoic tectonics, metamorphic transformations, and shear zone dynamics.

FUTURE WORK:-

After completing research on the tectono-metamorphic evolution of the Gurabanda area, further studies can focus on advancing our knowledge of geodynamic processes, resource exploration, environmental impact, and regional tectonic significance.

I. Regional Correlation and Comparative Studies: Correlation with other shear zones and cratonic boundaries in the Indian subcontinent (e.g., Dharwar Craton, Chotanagpur Gneissic Complex, and Bastar Craton).
II. Detailed Geochronological and Thermobarometric Studies
III. Structural and Kinematic Analysis of the Singhbhum Shear Zone: 3D structural modelling, Paleostress reconstruction, Detailed microstructural analysis
IV. Economic Geology and Mineral Resource Exploration: Identification of new mineralized zones based on tectono-metamorphic signatures, AI/Machine Learning-based predictive modeling for mineral exploration. Hydrothermal alteration and ore fluid geochemistry studies to determine mineralization potential.
V. Monitoring groundwater and surface water quality influenced by metamorphic processes.

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